

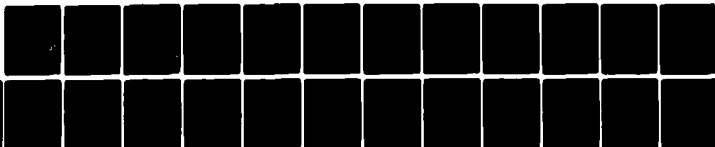
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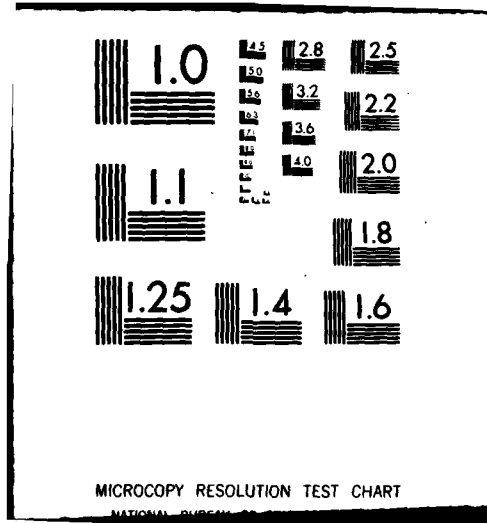
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ware programs the BDRS accepts digital data input from analog sources and magnetic tape. Output from the system will consist of proof plots, track-line generation, data base access and editing, and "quick look" capabilities into the data base. New developments contained in the system are: Voice recognition digitization system which allows the input of sounding data by spoken word; digitization of fathograms and the subsequent proof-plot generation using ship's log and the digitized soundings; and, the ability to geo-section portions of the data base using circular, triangular, or polygonic searches to define user areas of interest.



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BATHYMETRIC DATA
REDUCTION SUBSYSTEM
(BDRS)

GORDON M. FRANK
JAMES P. MORAN
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DEFENSE MAPPING AGENCY HYDROGRAPHIC/
TOPOGRAPHIC CENTER
WASHINGTON, D.C.

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BATHYMETRIC DATA REDUCTION SUBSYSTEM

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ABSTRACT

The Bathymetric Data Reduction Subsystem (BDRS) represents a new concept in bathymetric data reduction processing. The BDRS is the primary support subsystem to the Bathymetric Information System (BIS). BIS is one of eight interactive data base systems to be developed under a global control system known as the Source Data Base System (SODS). SODS will provide users with both centralized access and information manipulation capability to these various information systems, including BIS. Users will have no direct access to BDRS, but they will be able to retrieve information from BIS through SODS.

Through the use of various software programs the BDRS accepts digital data input from analog sources (such as smooth sheets and fathograms/echograms) and magnetic tape. Output from the system will consist of proof plots, track-line generation, data base access and editing, and "quick look" capabilities into the data base. New developments contained in the system are: Voice recognition digitization system which allows the input of sounding data by spoken word; digitization of fathograms and the subsequent proof-plot generation using ship's log and the digitized soundings; and, the ability to geo-section portions of the data base using circular, triangular, or polygonic searches to define user areas of interest.

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I. Introduction

The Bathymetric Data Reduction Subsystem (BDRS) represents a new concept in bathymetric data reduction processing in the Scientific Data Department of the Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC). By the use of state-of-the-art technology in both hardware and software, the design of the BDRS will provide an initial influence on future data base structured systems to be developed at DMAHTC.

A. Objective

With increased emphasis on the acquisition of bathymetric data in a digital form, the BDRS will provide a means of storing, retrieving and manipulating data to provide products for the support of nautical and bathymetric charts. The BDRS will also provide a means of comparing incoming data with current or up-to-date data for accuracy and integrity. This added feature at DMAHTC will have the capability of identifying where good data exist and where more data should be acquired.

B. Development

The BDRS was developed by the Synectics Corporation (Fairfax, VA.), under contract with the Rome Air Development Center (RADC) and the Defense Mapping Agency. Synectics Corporation performed both the system requirements study and analysis/design activities, which resulted in software/hardware specifications for the BDRS. Much of the software used in the development of the BDRS had been previously developed for use on the UNIVAC 1108 mainframe. It was the job of the primary contractor (Synectics) to adapt and develop new software into a mini-computer environment with on-line (interactive) capability

and to provide the appropriate peripheral devices for each on-line function. The function of RADC was to manage the development and system implementation by Synectics. DMAHTC provided the technical expertise to the bathymetric data handling capability and function at the Center. With all three components working together, the BDRS became a unique on-line data reduction subsystem with bathymetric data base capabilities.

II. Integration With Other HTC Systems

The BDRS is an integral part of the conceptual Bathymetric Information System (BIS), which is vital to the Global Plan (Phase I) of the Source Data Base System (SODS). Its purpose is to assist in providing timely information to authorized DMA users (both internal and external) of compilation, source, and index data.

In Figure 2-1, the BDRS is the "work-horse" in this scheme. Because basic analysis and evaluations will be constantly processed to update the BIS for new real-time processing, users will have to initiate a request through the BIS where it is validated giving the requester access to the indices showing the areas of coverage, reliability of data, accuracy, and geographics.

The BDRS must maintain a flexible posture to support the various interfaces for the expansion of existing functions. These functions include software programs, digitization, analysis, and hardware operations.

Support to worldwide weapon systems is a paramount MC&G requirement at DMAHTC. Additionally, the Center receives thousands of data points, track lines, surveys, and similar data each month from naval sources, government agencies and private firms. These data must be quickly synthesized and

readied for use by the analysts for chart production. The incoming data, which have been evaluated by the hydrographic analyst, can be reduced and verified, if proper documentation accompanies the submission. It is estimated that collected source data can be readied for use quicker than some current methods using semi-automatic ADP systems.

The BDRS must also be compatible with the Lineal Input System (LIS) whose function it is to reduce analog data to a digital format. The main cost-saving here is the speed with which a nautical chart can be produced or corrected, and reduce data redundancy and manual files.

Finally, as the BDRS is integrated with other systems at DMAHTC, it is not intended to be a "cure-all" system or a substitute for all existing methods. Instead, it is a system which has been designed to apply state-of-the-art technology to MC&G areas, specifically to the hydrographic product, and to effectively reduce the total costs of producing a usable, safe, and accurate product.

III. Data Inputs

DMAHTC receives data from worldwide sources. These data fall into several general categories of hardcopy and softcopy mediums, where many hardcopy holdings predate the 20th century.

The hardcopy medium consists of survey smooth sheets, random track charts, program listings, sounding logs, and echograms. These data can be summarized as analog type. The softcopy medium includes magnetic digital tapes, and occasionally a card deck. These data can be conveniently summarized as numerical type input. A detailed explanation is given about the general inputs of analog and numerical data below.

A. Analog Data

The classification of analog data would include mostly survey smooth sheets, random tracks, and echograms which consist of lineal and point data. These data, graphically represent the physiography of the ocean floor. It is obtained by transiting predesignated lines over an area or surface, either creating a controlled pattern (survey) of sounding data or data gathering (random), which is secondary to the original mission of the vessel. Both types of data are important needless to say, but the random track data can be and often are the only data available in which to build to a nautical product. Echograms usually accompany both random and survey data. They are especially useful for verification purposes. Subsequently, all data (survey and random) must be analyzed for horizontal and vertical accuracies. The analysis is measured against a predetermined standard for accuracy. An example would be the southern oceans where the standards are usually lower due to the unavailability of substantive information which is the result of fewer ships in transit compared with the northern oceans. In contrast, the North Atlantic region has a higher evaluation standard, particularly in the vicinity of shipping lanes. Essentially, the evaluation of bathymetric data is relative to a geographical region and the density of available quality data in the same region. The BDRS is designed to sort and track these various parameters for data evaluation.

B. Numerical Data

Numerical data are sounding logs, digital magnetic data tapes, or single point positions and soundings. Presently, much of these data must be digitized and manually compared to the associated source such as a ship's track for evaluation. The advent of the BDRS can greatly simplify this process and make it less tedious than current methods allow. A comparison is made and finally evaluated with

visible overlays plotted to the scale of the track or echogram. This procedure immediately illustrates whether the data are valuable for storage purposes. Over the last few years, much of the data submissions to the Center are in a digital format which make it easier to plot and verify, after the header information has been deciphered, if the data package has been properly documented. Over the years, DMA has had good success with the data it has received from the U.S. Navy, petroleum companies, National Ocean Survey (NOS), Naval Research Laboratory (NRL), and the Naval Oceanographic Office (NAVOCEANO). The merchant marine community is also an excellent source of information; however, most of their submissions are through conventional means (hardcopy) and random in nature.

Lastly, Figure 3-1 shows a simplification of the data types received and how they are interfaced within DMAHTC to support the worldwide users of hydrographic information and other specific data.

IV. Data Outputs

The BDRS will be used as a support tool primarily for the Scientific Data Department at DMAHTC. However, its information can be used by anyone requiring access to bathymetry in a digital form.

Basically, the BDRS has outputs of four types. They are: plots, graphic displays, summary reports, and magnetic tape files.

A. Plots

Plots are any output which will eventually be produced from a readable tape on a Xynetics or Calcomp Plotter. Plots of this type include: Proof plots for verification against existing data plots, General Bathymetric Chart of the Ocean (GEBCO) track line plots of ship tracks registered while soundings were being recorded, and plots of a geo-sectioned area contained in the data base (geo-sectioning will be described later in this paper).

All plots output by the BDRS provide the analyst with a reference sheet of what data are contained in the BDRS data base. Plots provide a vital support tool for the preparation of source information packages, which are the first step in producing a new chart.

B. Graphics Displays

The BDRS also can output data in the form of a "quick look" display of the digital data. This can be performed on one of three CRT display devices. This "quick look" feature allows an analyst to examine quality of data available in a region, without having to wait for a hardcopy output to be constructed. The BDRS also allows access to any textual or source identification information that a unique document identifier has associated with it. The unique document or data holding is referenced by what is called a document number. This is an account number, which is assigned to a unique group of data when it arrives at the Center. The BDRS can output all document numbers in a region and describe the area encompassed by each document number.

C. Summary Reports

Whenever a conversion, or any other batch process takes place on the BDRS, a record of the transaction is stored and can be retrieved and easily printed using the line printer. Information contained on these reports identifies all old and new parameters that were involved in the conversion process. In addition, when a retrieval of the BDRS data base is required using a document number or geographics, a summary report is produced to summarize what a user created. This feature can be considered a supervisory function of the BDRS.

A dump of all data blocks, entered into the data base or contained in a geographics file, can also deliver a summary report on the line printer, allowing the user to do a sounding-by-sounding check of the data.

D. Magnetic Tape Files

A file can be dumped to magnetic tape for input into other system routines. Output is executed using BDRS operating system commands. Digitized data can also be output to tape using a software routine, which outputs an octal dump of the data.

V. System

A. Hardware

The BDRS consists of predominately off-the-shelf equipment and can be acquired from vendors by way of their individual product lines. An illustration of the BDRS hardware is given in Figure 5-1.

The computer used for the BDRS system is a Data General Corporation (DGC) Eclipse C-300 with a 92 MB Data General Disk Unit. The disk is the mass storage device on the BDRS and contains all operating system software, user generated systems software, and data base information. The Eclipse is a 16 bit machine, 128k word core memory, with memory capacity to 256k words with optional map. Two 9-track Data General magnetic tape drives are also linked to the main Central Processing Unit (CPU) for tape input/output functions.

The BDRS supports two Data Automation Digitizing Tables. The first, known as Station 1 (See Figure 5-2), consists of a digitizing table, a Data Automation standard 3-inch field of view cursor, with a 16-key keyboard and a Tektronix 4010 graphics display terminal. The table has a free-cursor electronic

digitizing system which provides a measurement accuracy of ± 0.005 inch over an area of 60 inches in the X direction and 42 inches in the Y direction. Measurement resolution is 0.001 inch with repeatability of ± 0.001 inch. The keyboard is used primarily for depth entry, but also can be used for editing and deleting functions.

The second table, known as Station 2 (See Figure 5-3), is basically the same unit as Station 1, except for one variation. Station 2 has a Threshold-500 voice entry system with a visual feedback display cursor. The Threshold Technology, Inc., system is an electronic speech recognition system, which automatically recognizes up to 32 spoken isolated words of up to 2.0 seconds duration each. This system is a prototype device which will be used as an alternative to the manual depth entry keyboard. This device can be trained by up to 99 users and serves as an aid to rapid depth entry input. The visual feedback cursor (developed by Data Automation Company) displays the spoken numeric, in the order of entry, on the cursor itself and allows for checking voice entry before the actual entry is recorded in the system.

Two automated drafting plotters are associated with the BDRS, but are not directly connected to it. One is a flatbed plotter manufactured by Xynetics Corporation (Model 1101). The other is a drum plotter manufactured by Calcomp Corporation (Model 936).

Peripherals contained on the system (See Figure 5-1) are a Centronics 101A Line Printer, a Data General 6012 CRT (which is used as the master terminal), and two dedicated devices, Data General 6052 Dasher terminal and a Tektronix 4014 Graphic CRT, which are used for data base operations only.

B. Operating System and Related Data General Operating Components

The operating system of the BDRS is Data General's Real-Time Disk Operating System (RDOS). It is a mapped system, which means it can run two user grounds (foreground and background) simultaneously. The primary interface between a user at the system console and RDOS is Data General's Command Line Interpreter (CLI). CLI is designed to accept command lines from a system console and translate them into operating system commands.

The BDRS is supported by Data General's INFOS. INFOS is a file management system, which will maintain the BDRS data base access and control capability. INFOS is intended to provide a concise, and flexible method for the creation and processing of sequential files, random files, indexed sequential files, and data base files.

Other system features of the BDRS include: Data General Text Editor, Data General Octal Editor, Data General Extended Arithmetic Processor, Fortran IV and Fortran V compiler, and power fail detect and automatic restart feature.

C. Software

The BDRS software can be described as being made up of three subsystems or modes with several special purpose routines. The three subsystems are: digitization, batch, and data base.

1. Digitization

As can be seen in Figure 5-4, the digitization process can input several types of information in several different ways. During what is called the initialization mode, chart information is entered and recorded for use later in the Batch conversion process. Once this information is entered, the chart, echogram

(fathogram), or smooth sheet is registered to the table. When a chart is registered it is said to be relatively referenced to the table X/Y coordinates. From 2 to 10 points can be referenced (the usual being just 4 points). These reference points are flagged by a geographic coordinate which later on in the batch subsystem can be directly merged with the X/Y data to produce a geographic file (GO). All X/Y positions on the table are entered via the two cursors at Station 1 and Station 2 (See Section V-A "Hardware"). Two methods exist on the BDRS for depth entry. Both Stations have the ability to enter depths manually via a keyboard assembly. Station 2 has a new function (as applied to bathymetry) of allowing depth entry via a spoken word. Station 2 (See Figure 5-3) has a Threshold Technology Model 500 voice entry terminal. Once an operator has trained his or her voice on this system (training means speaking in a consistent manner into the system's microphone and allowing a digital vocal pattern to be defined), an entry of depth can be registered both visually and on disk.

The digitization processes' most important manner of operation is known as Master Mode. This mode controls all inputs or operator commands selected by the user. Five subfunctions exist under master mode and the majority are accessed via the digitizing tables' 5-pushbutton cursor. Three of these subfunctions control the input of data (Trace Mode, Depth-entry Mode, and Discrete Point Mode). Trace Mode inputs any linear or continuous feature such as shoreline, contour, or echogram trace. Trace mode also inputs any feature which consists of a continuous line segment. Depth-entry Mode allows the user to input independent depths using either the manual entry system or the voice entry system. Discrete Point Mode allows the entry of individual grid ticks where they can be used for reference to a grid or projection type relating to the source material. Two other subfunctions exist on the BDRS which allow corrections or modifications

to be made. The first is known as review mode which allows the review or examination of everything entered via the previously described input functions. A window relative to the area positioned by the cursor is set up, and all entries within this window are flashed on the Tektronix 4010 CRT for visual verification of all entries. The other subfunction used for verification or modification is the edit mode. This mode allows the operator to delete, change, or modify any feature such as a sounding entered during any of the first four modes.

Outputs from the Digitization process are in the form of three files (See Figure 5-4). The Data File (DF) holds all of the X/Y data recorded by the cursor. The Header File (HF) holds all header information that describes a unique feature. The Index File (IF) holds all source information that will be used in the batch conversion process. These three files can all be deleted using RDOS (See Section V-B) commands from the Background Master terminal.

The BDRS also has the unique ability to digitize an echogram and allowing it to be converted in batch to a file that can be entered into the BDRS data base. When digitizing an echogram (depth verses time analog source), trace mode is used and the depth curves contained on an echogram are recorded. When a change of scale or when a long echogram has to be reregistered, a new file is created (FF-Fathogram) which holds all change information.

As can be seen in Figure 5-4 a job which has already had data entered can be reentered, and new data can be appended to it. When this happens the job must be reregistered and checks must be made against residuals to assure that the same chart has the same "day one" registration. Residuals are error parameters which tell how far away from the original (day one) registration a chart is the second or third time it is used. Ideally, day one registration should show zero residuals, and day two and after should be no greater than .005 inch off (residuals are measured in units of .001 inch).

2. Batch

The batch subsystem provides the interfacing of the digitizing subsystem to the data base subsystem. Each function can be described as being standalone, meaning it performs one function and one function only. General categories of all batch subsystem functions are: Plotting functions, conversion functions, and input/output batch routines. (See Figure 5-5 for a diagram of batch subsystem data flow).

When plotting functions are defined, reference is made to any routine in batch which produces a Xynetics or Calcomp plotter readable magnetic tape. These routines include Proof Plot (used to plot an overlay of previously digitized soundings), Scaling Echogram (used to plot an overlay of a previously digitized echogram/fathogram), and Plot Driver (which is used to create a Xynetics or Calcomp readable tape of the previous two routines). A routine called GEBCO Track Line is also contained in subsystem batch and is used to plot "track lines" or ships course across the ocean.

Conversion routines used in this subsystem cause a file or files to be changed over to a new format. The most important of these is a routine called Table to Geographics conversion. When a job is completed on one of the two digitizing tables, the files created are said to be in table (X/Y) coordinates. This routine takes the table file and converts it to a geographic file (latitude, longitude, depth). This is an important step because the BDRS data base is stored in geographic coordinates. When an echogram is digitized another routine is run which requires an echogram table file and the previously entered ship's log file. These two are merged, and a geographic file is produced. This file can now be entered into the data base in the same way as any other geographic file. Other routines contained in the batch subsystem include Geographics to Table

conversion (used to create a new table file from a previously created geographic file), Depth Adjustment (used to filter depths in dense data regions), and Datum Shift (which converts from one datum to another).

Input/output batch routines are also used to capture data previously created on other systems. Systems to be interfaced with the BDRS are the Lineal Input System (LIS) (the data digitizing system used in the Hydrography Department at DMA), and UNIVAC 1108/81 holdings of previously digitized soundings, held on tape and accessed off-line by batch processes. The BDRS batch subsystem can also transfer files to and from magnetic tape. The output from this routine is an octal dump which can be used on the system.

3. Data Base

The BDRS data base subsystem is designed to create, update, and maintain a viable holding for bathymetric data. The data base utilizes Data General's INFOS file management system. The design within the data base consists of three unique modes of operation: Master Mode, On-Line, and Batch (See Figure 5-6 BDRS DATA BASE DATA FLOW).

Master Mode allows a system supervisor the capability to assign a log-on password and read and or write privileges to the data base. The above parameters can be deleted or modified to accomodate the needs of the user. The system supervisor can also reinstate or delete those documents flagged logically for deletion during the on-line process. Basically Master Mode is a tool designed to insure data base integrity.

The On-Line Mode is designed to input document source description records and is capable of random geographic queries of the data base. To support this function the Data General (DG) 6052 and TEKTRONIX 4014 graphic CRT's are used, respectively (See Sec. V-A "Hardware"). The user can input, review/modify, or delete source information via the DG 6052 CRT; remembering from master mode he/she was assigned a password to read and/or write privileges to the data base. To input a document source the user defines the geographic area (bounding rectangle) and a 10-digit document number. The document number is assigned to any data (analog or tape) which is received by the Scientific Data Department for catalog purposes. The source descriptive record(s) consist of unique parameters defining the type and quality of data associated with the document. These values are entered and can be reviewed or modified. If modification is desired, the user can update any parameter as required. The deletion process allows the user to logically delete the entire document or a particular sheet(s) of that document. Only the system supervisor can physically delete any data from the data base. This is another tool to insure data base integrity.

Continuing with on-line, geographic queries can be performed by both terminals. Utilizing the DG 6052 the user queries the data base by inputting 2 to 8 points. The retrieved data displays the document(s) for review. Another feature is point search. This allows the user to define an exact location (latitude and longitude) to search the data base for one data value. This is extremely useful when questioning the validity of a sounding value. The Tektronix 4014 allows the user to geographically query the data base and display the retrieved data graphically. The graphic display consists of the ship's track as stored in the data base and referenced by the geographics used for that query. The retrieved data can be used as an output file to be plotted for the user.

The Batch Mode of the data base subsystem allows the user to interactively load, query, and logically delete data from the data base. The load process requires a BDRS standard geographic file, the document, and respective source descriptive parameters. The standard geographic digital file is transferred with its respective source descriptive parameters into a hierarchical data base. A query of the data base is accomplished by document or geographic retrieval. The document retrieval searches the "geographic" data base and displays the document(s) and the associated source descriptive parameters. The geographic retrieval allows the user to query the data base by two methods, geographically and logically. A logical query can be by a ship's name and or data evaluation. (See On-Line Mode). Geographic sectioning of the data base retrieves data by a circular, triangular or polygonic method. (See Section VI C). The output from geo-sectioning is plotted on the Tektronix 4014 graphic CRT in the form of track lines. A list of all documents contained within the defined geographical area will be displayed. This display can be transferred to a BDRS geographic formatted file. The final output of a geographic query is used to produce a computer plot via the Xynetics or Calcomp plotters. Finally the data base Batch Mode allows for logical deletion of a document (See Master Mode). A report is generated from the line printer to provide the user with a hard copy summation for each request during the Batch Mode.

VI. Highlights of the System

A. Voice Recognition Digitization as Applied to Bathymetry

The BDRS allows the input of soundings by a different method than has been previously employed in a digitization process. Station 2 (See Section V-A "Hardware") is connected to a Threshold Technology, Inc - Model 500 voice data entry terminal. This hardware unit allows a user to input independent numeric data by spoken word. Once the values of a sounding are spoken into the machine, a user can enter the sounding into a user defined file as a X, Y, Z value. Numeric values are both displayed back to the user on the data entry terminal as well as on a special Data Automation LED display cursor. Having the values displayed in this way allows real time checks of each sounding before it is entered into a file. The voice system has several advantages and disadvantages. One advantage is that the operators hands are free to hold the cursor at a static position, which allows for a more accurate entry of the X, Y position. This system also allows up to 99 different voices to "train" the system. A disadvantage of the voice system is that it is an early version of Threshold's voice system, and it does not accept spoken words as fast as some of the later models. The system can be field-upgraded with new hardware, which will allow it to handle a much larger vocabulary and to be much faster. For purposes of the BDRS, however, the voice entry system allows an alternative to manual entry, and it does allow reasonably fast data entry.

B. Echogram (Fathogram) Digitization and Verification

A very significant development of the BDRS is the ability to digitize an echogram, convert it to geographic coordinates, and examine the recording ship's track by displaying it on a CRT screen. An echogram shall be defined as any graph

that contains depth versus time axes and a copy of the recording ship's log of geographic fixes, loxodrome bearings, and ship velocity changes. Up until this point, all previous abilities to digitize echograms had output X, Y depth formats. The BDRS produces geographic - depth positions, and because of the geographic nature of the BDRS data base (See Section V-C "Software"), echograms can be entered directly into the data base, and plots of this data can be made using the BDRS Geo-Sectioning routines. This is a significant improvement over previous hand calculations that took place when utilizing an echogram (fathogram).

C. Geo-Sectioning of the Data Base

Geo-Sectioning (geographic) is defined as the ability to access a data base by defining geographic coordinates (in the BDRS one can define 2 to 8 points) or bounds and by outputting all information contained within this specified area to a display device. The BDRS allows a user to define a circular section (2 points), a triangular section (3 points) or a polygonic section (4 to 8 points) of anywhere in the global data base and to output it to a CRT screen or plotter readable coordinates. The major emphasis here is on the phrase "anywhere in the global data base" because the BDRS, for the first time can section data on either side of the prime meridian and north or south of the Equator. This is a breakthrough development, and Synectics Corporation should be given full credit for developing the algorithm. The BDRS data base is geographic in nature and because of this the sectioning routine outputs data in the form of a geographic file. This file can be input into many other BDRS batch routines and converted to a plot of the sectioned area. The plot can then be utilized as a product in support of the production effort of nautical charts.

VII. Conclusion

The Bathymetric Data Reduction Subsystem (BDRS) is one of the newest interactive data bases in the Department of Defense. The BDRS was conceived for the support of weapons systems that require worldwide hydrographic data. Being interactive is cost-saving in that real-time turnaround permits rapid editing and modification of the data base. Moreover, advanced editing and updating features allow data entered to be kept at maximum accuracy and integrity with minimum redundancy. With such an accurate data base, mission goals of DMAHTC can be met more rapidly and with improved accuracy.

It is necessary to note that the BDRS is a prototype unit and is still under testing for compatibility with present DMAHTC support applications. At present the system seems to fit in well with the Center's current compilation and source package preparation flow, and it appears to be a workable application of automation at DMAHTC. The current system will have to be expanded, however, with respect to memory, as more and more data are input into the system. This should be no problem because of the Data General Eclipse C-300's compatibility with new peripheral equipment (such as disk units) and software application programs.

In conclusion, the BDRS is a fine mixture of components which perform a specific function relative to bathymetry. It has a place at Defense Mapping Agency Hydrographic/Topographic Center and will influence the creation of future data base systems at the Center.

VIII. ILLUSTRATIONS

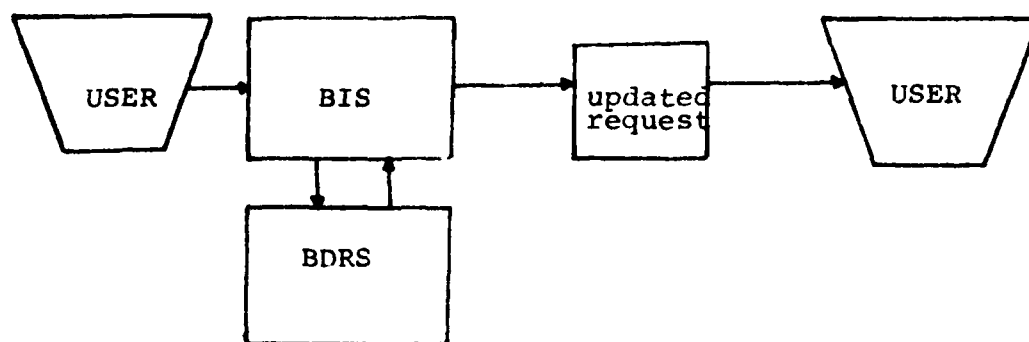


FIGURE 2-1 BATHYMETRIC INFORMATION SYSTEM
CONCEPT

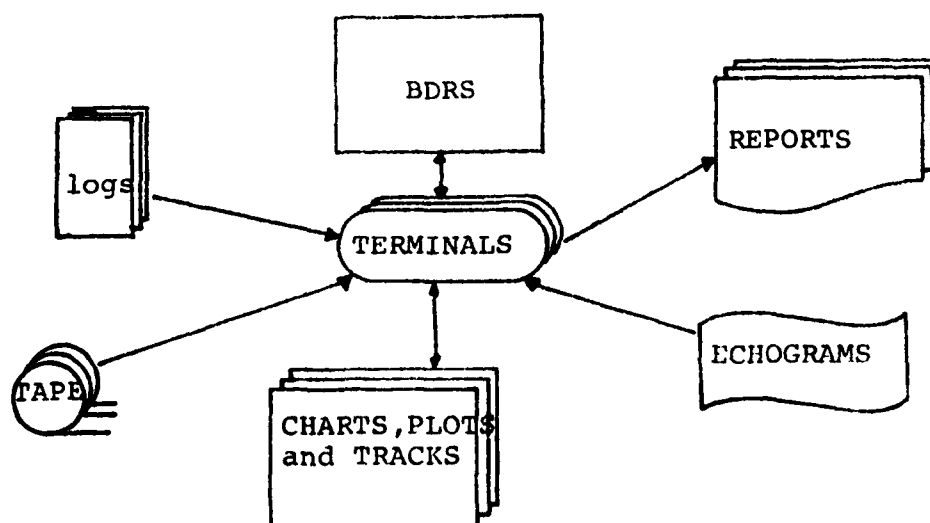


FIGURE 3-1 BDRS SIMPLIFIED INTERFACES

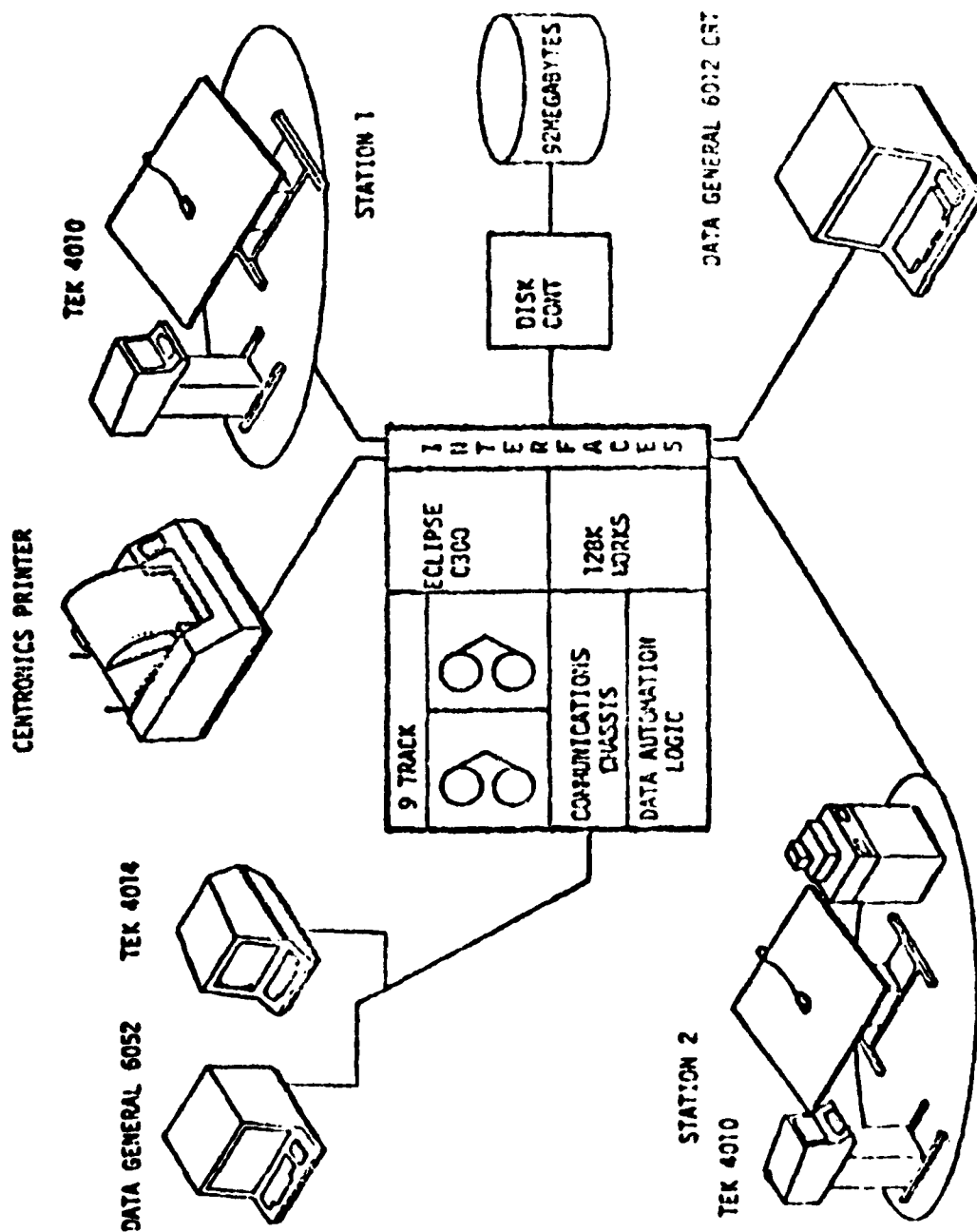


Figure 5-1 BDRS Hardware Configuration

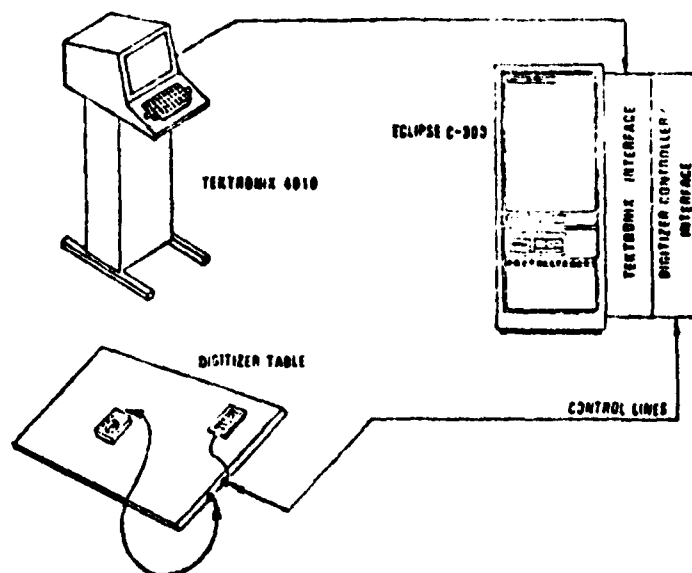


Figure 5-2 Station 1

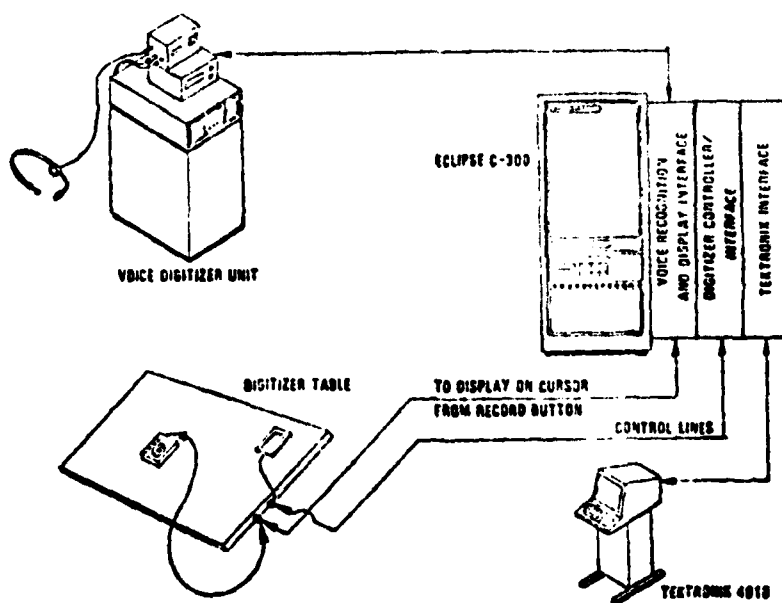


Figure 5-3 Station 2

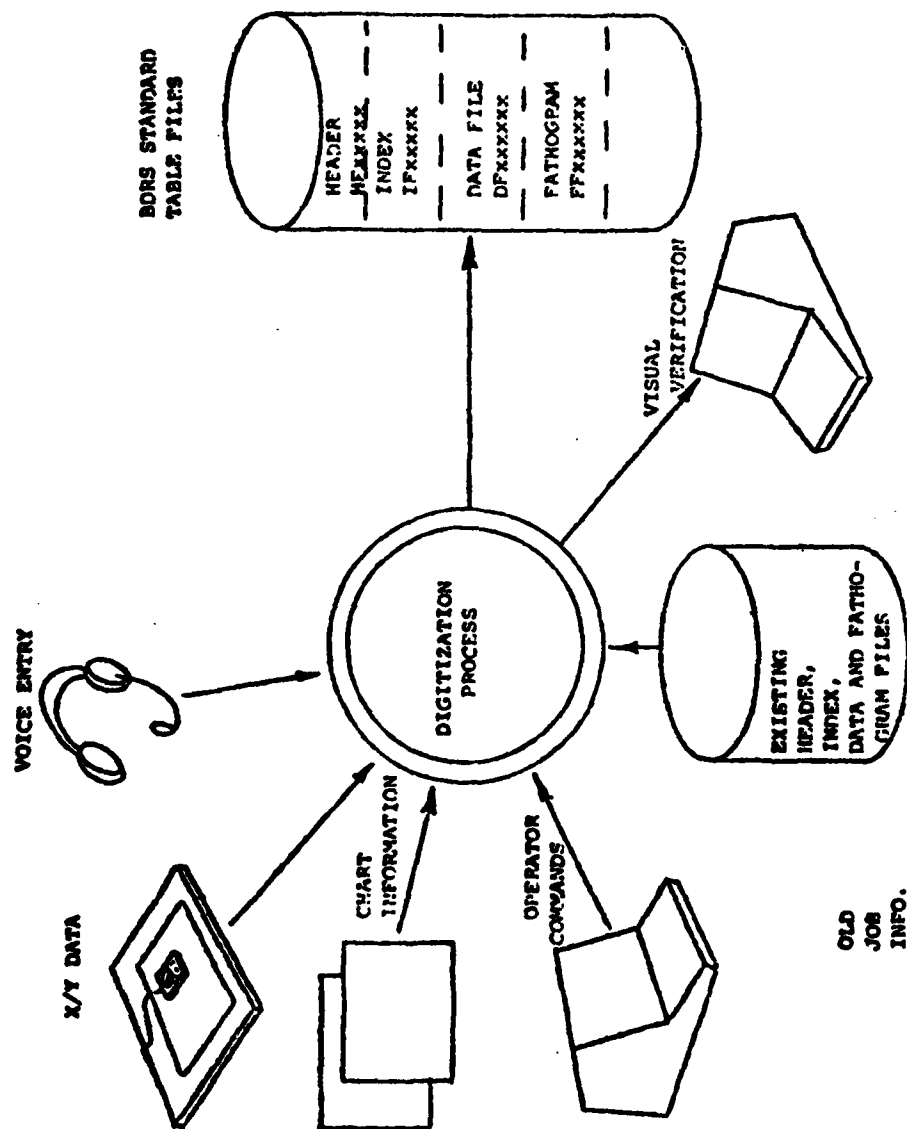


Figure 3 - 4 Digitization Input and Output

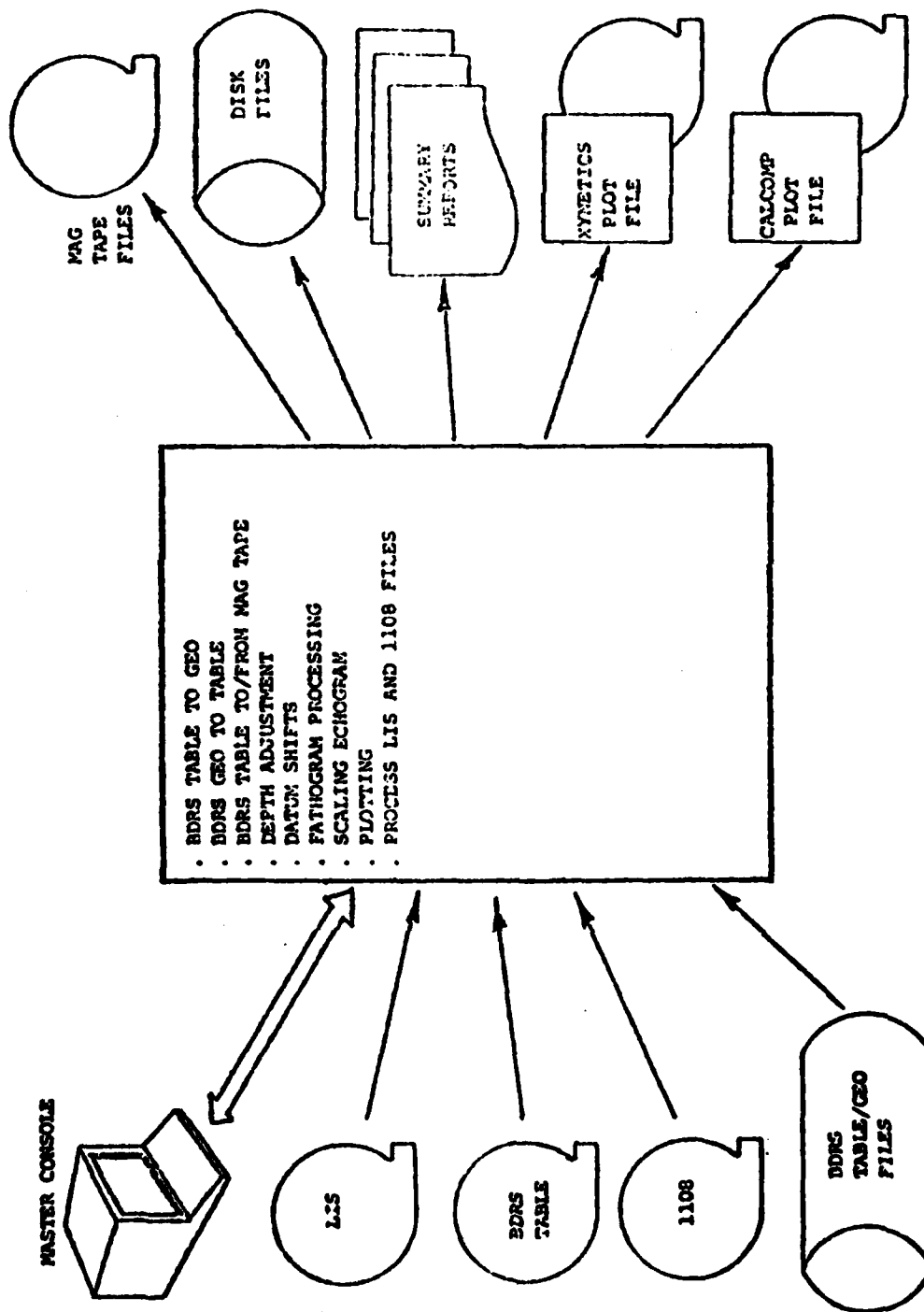


Figure 3 - 5 Batch Subsystem Data Flow

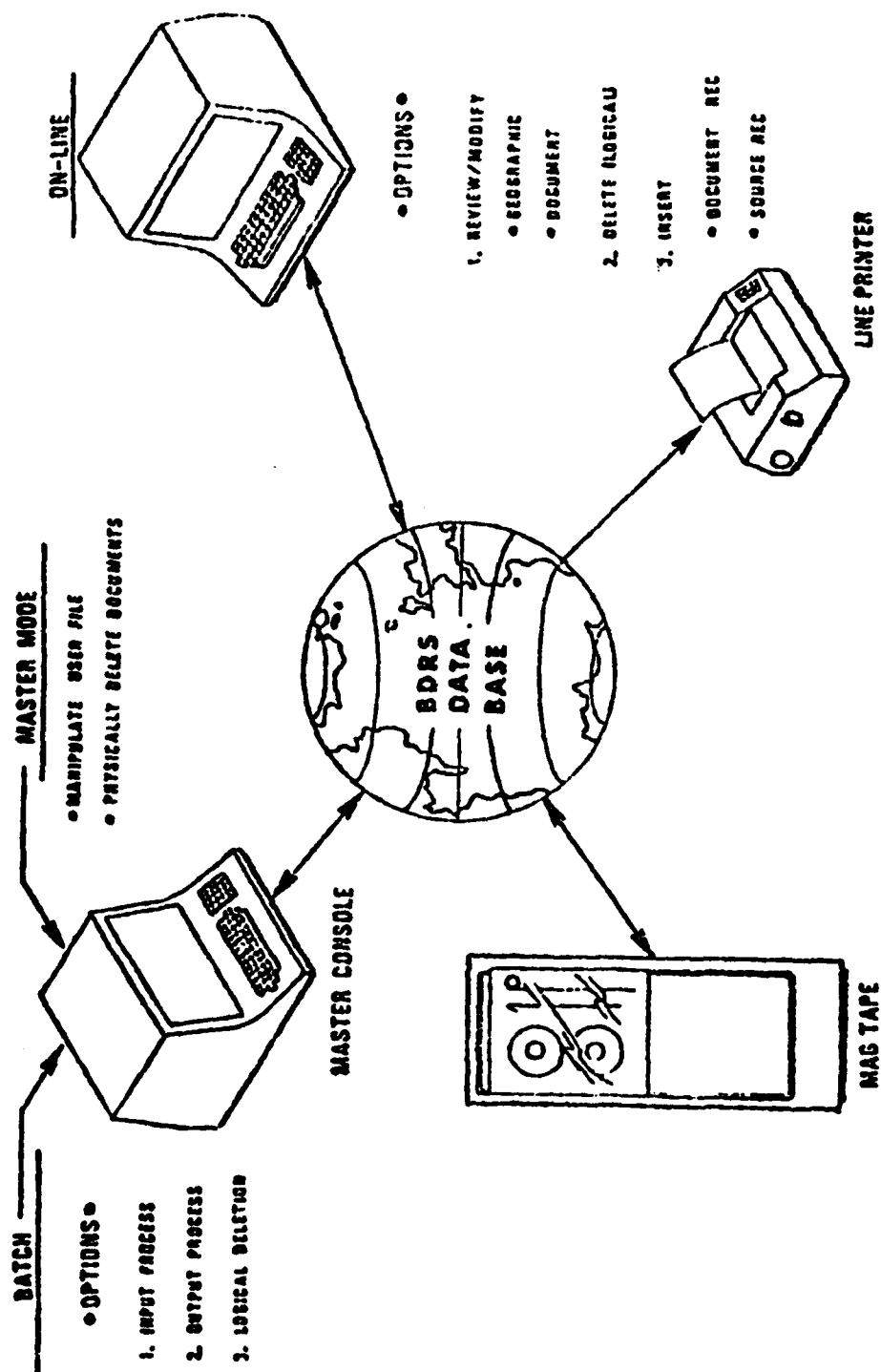


Figure 5 - 6 BDRS Data Base Data Flow

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